

## CLAIMS

1. A method of predicting a fuel injector tip temperature (FITT) in an engine, comprising the steps of:  
estimating an initial temperature of the fuel injector tip;  
calculating a steady state temperature of the fuel injector tip;  
5 determining a filter coefficient as a function of a rate of airflow into the engine; and  
predicting the FITT as a function of the initial temperature and the steady state temperature, wherein the steady state temperature is filtered into the FITT at a rate  
10 determined by the filter coefficient.
2. The method of claim 1 wherein the estimating step is determined as a function of a ratio between a shutdown injector temperature and a shutdown temperature of an engine coolant.
3. The method of claim 2 wherein the ratio is adjusted to decay as a function of a soak time of the engine.
4. The method of claim 3 wherein the ratio is adjusted to exponentially decay as a function of the soak time.
5. The method of claim 4 wherein the initial temperature is determined according to:

$$T_{injector\_restart} = T_{coolant\_restart} \left( 1 - \left( 1 - \frac{T_{injector\_shutdown}}{T_{coolant\_shutdown}} \right) e^{-K(Time_{soak})} \right)$$

- wherein K is a constant,  $T_{injector\_restart}$  is the initial temperature,  
5  $T_{coolant\_restart}$  is a temperature of the engine coolant at restart,  
 $T_{injector\_shutdown}$  is the shutdown injector temperature,  $T_{coolant\_shutdown}$  is the shutdown temperature of the engine coolant, and  $Time_{soak}$  is the soak time.

6. The method of claim 1 wherein the steady state temperature is calculated as a function of at least an engine coolant temperature and an air temperature.
7. The method of claim 6 wherein the steady state temperature is calculated as a weighted average.
8. The method of claim 7 wherein the weighted average is offset by an offset value determined as a function of exhaust gas flow.
9. The method of claim 1 wherein the predicting step comprises filtering the steady state temperature into the FITT with a lag filter at a rate determined by the filter coefficient.
10. The method of claim 9 wherein the predicting step comprises providing a feedback value of the FITT to the lag filter.
11. The method of claim 1 further comprising the step of triggering a hot restart purge (HRP) if the predicted temperature exceeds a pre-determined threshold value.
12. A method of predicting a fuel injector tip temperature (FITT) in an engine, the method comprising the steps of:

calculating a steady state temperature of the fuel injector tip as a function of at least an air temperature and a current temperature of an engine coolant;

determining a filter coefficient as a function of a rate of airflow into the engine; and

predicting the FITT by filtering the steady state temperature into the FITT at a rate determined by the filter coefficient.

13. The method of claim 12 further comprising the step of estimating an initial temperature of the fuel injector tip as a function of a ratio between a shutdown injector temperature and a shutdown temperature of the engine coolant, wherein the ratio is adjusted as a function of a  
5       soak time of the engine.
14. The method of claim 13 wherein the predicting step comprises using the initial temperature as a first value of the FITT.
15. A method of predicting a fuel injector tip temperature (FITT) in an engine, comprising the steps of:
- estimating an initial temperature of the fuel injector tip as a  
          function of a ratio between a shutdown injector  
5       temperature and a shutdown temperature of an engine  
          coolant, wherein the ratio is adjusted as a function of a  
          soak time of the engine  
          calculating a steady state temperature of the fuel injector tip as  
          a function of at least an air temperature and a current  
10       temperature of the engine coolant;  
          determining a filter coefficient as a function of a rate of airflow  
          into the engine; and  
          predicting the FITT as a function of the initial temperature and  
          the steady state temperature, wherein the steady state  
-15       - - - - - temperature is filtered into the FITT at a rate  
          determined by the filter coefficient.
16. An apparatus for predicting a fuel injector tip temperature (FITT) in an engine, the apparatus comprising:
- means for estimating an initial temperature of the fuel injector  
          tip;  
5       means for calculating a steady state temperature of the fuel  
          injector tip;

means for determining a filter coefficient as a function of a rate  
of airflow into the engine; and  
means for predicting the FITT as a function of the initial  
10 temperature and the steady state temperature, wherein  
the steady state temperature is filtered into the FITT at a  
rate determined by the filter coefficient.

17. An apparatus for predicting a fuel injector tip temperature (FITT) in an  
engine, the apparatus comprising:  
a first module configured to estimate an initial temperature of  
the fuel injector tip;  
5 a second module configured to calculate a steady state  
temperature of the fuel injector tip;  
a third module configured to determine a filter coefficient as a  
function of a rate of airflow into the engine; and  
a fourth module configured to predict the FITT as a function of  
10 the initial temperature and the steady state temperature,  
wherein the steady state temperature is filtered into the  
FITT at a rate determined by the filter coefficient.

18. A digital storage medium having computer-executable instructions  
stored thereon, the instructions comprising:  
a first module configured to estimate an initial temperature of  
the fuel injector tip;  
5 a second module configured to calculate a steady state  
temperature of the fuel injector tip;  
a third module configured to determine a filter coefficient as a  
function of a rate of airflow into the engine; and  
a fourth module configured to predict a fuel injector tip  
10 temperature (FITT) as a function of the initial  
temperature and the steady state temperature, wherein  
the steady state temperature is filtered into the FITT at a  
rate determined by the filter coefficient.

19. A vehicle having an engine, a fuel injection system for the engine having at least one fuel injector tip, and an engine controller module having a processor and a memory configured to store computer-executable instructions for the processor, wherein the instructions  
5 comprise:  
an estimating module configured to estimate an initial temperature of the fuel injector tip;  
a calculating module configured to calculate a steady state temperature of the fuel injector tip;  
10 a determining module configured to determine a filter coefficient as a function of a rate of airflow into the engine; and  
a predictor module configured to calculate a fuel injector tip temperature (FITT) a function of the initial temperature  
15 and the steady state temperature, wherein the steady state temperature is filtered into the FITT at a rate determined by the filter coefficient.
20. The vehicle of claim 19 further comprising hot restart purge (HRP) logic configured to receive the predicted temperature and to trigger a hot restart purge of a fuel canister if the predicted temperature exceeds a pre-determined threshold.